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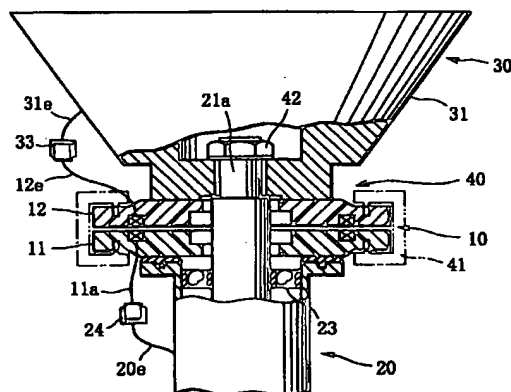
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(54) METHOD OF ASSEMBLING ISOLATION TRANSFORMER

(57) A stator core (11) is mounted to a stationary member (22) and electric wiring on the stator side is carried out, to thereby assemble a first sub-module (20), and a rotor core (12) is mounted to a rotary member (21) and electric wiring on the rotor side is carried out, to thereby assemble a second sub-module (30). Thereafter, the first and second sub-modules are assembled together, with the stator core and the rotor core opposed to each other, whereby a separable transformer is assembled. A guide member (27), having first and second reference faces defining reference positions in diametrical and axial directions of the rotation shaft (21), respectively, is provided in the rotation shaft (21) rotatably supported by the stationary member and mounted with the rotor core. Mounting positions of the cores are determined with use of the guide member, thereby precisely setting a center position between the cores and a gap length  $g$ .

FIG. 1



## Description

### TECHNICAL FIELD

[0001] The present invention relates to a method of easily and precisely assembling a separable transformer, including primary and secondary cores disposed opposite to each other and adapted to carry out contactless signal/energy transmission between the cores, e.g., a rotary-type separable transformer (rotary transformer) having primary and secondary cores one of which is mounted to a rotary member. More particularly, the present invention relates to a separable-transformer assembling method which is capable of performing electric wiring for primary and secondary cores with ease and of sufficiently improving the assembling accuracy in respect of a gap length defined between the cores.

### BACKGROUND ART

[0002] A separable transformer, including primary and secondary cores disposed opposite to each other, has a function of transmitting signal or energy between the cores in a contactless fashion by means of electromagnetic coupling. Especially, a rotary-type separable transformer, called a rotary transformer, including a stator core and a rotor core (primary and secondary cores) respectively mounted to a stationary member and a rotary member rotatably supported by the stationary member, is widely used in various applications.

[0003] In general, a separable transformer (rotary transformer) of this type is provided in the form of a one-piece module that is comprised of primary and secondary cores (stator and rotor cores) assembled in advance into one piece, with these cores disposed opposite to each other. For instance, the modularized separable transformer (rotary transformer) is incorporated into an automotive steering unit and serves to transmit explosive energy of an air bag apparatus mounted to a steering unit or transmit a signal to a cruise control unit.

[0004] The assemblage of an automotive steering unit is generally performed in a final assembling stage in a main assembly line where an instrument panel, a console box, a seat and the like are mounted to a vehicle body. Thus, a space available for the assemblage of a steering unit is largely limited. Under such circumstances, an operator is obliged to keep a hard posture during the operation of mounting a separable transformer to a steering unit and electrically connecting primary- and secondary-side component parts of the separable transformer individually to electric circuits of a shaft module (stationary member) and a steering wheel module (rotary member).

[0005] In the case of a separable transformer comprised of primary- and secondary-side component parts that can be assembled in advance separately from each other, it is conceivable that the assemblage of the separable transformer may be made at the same time when the separable transformer (rotary transformer) is mounted to a steering unit. In this case, however, the separately assembled primary- and secondary-side component parts must be incorporated into the steering unit with a considerably high degree of assembling precision. Further, it is very difficult to precisely align axes of both the primary and secondary cores (stator and rotor cores) of the separable transformer (rotary transformer) with each other and to set the distance (gap length) between the opposed cores with high accuracy so as to permit the separable transformer to exhibit intended capabilities.

[0006] The present invention has been accomplished in view of the above circumstances, and it is an object of the present invention to provide a method capable of assembling a separable transformer with improved workability.

[0007] Especially, an object of the present invention is to provide a method of assembling a separable transformer, which makes it easy to carry out electric wiring operations for primary- and secondary-side component parts of the separable transformer.

[0008] Another object of the present invention is to provide a method of assembling a separable transformer, which is capable of precisely setting a positional relationship between a primary core and a secondary core by a simple operation procedure.

[0009] To achieve the above objects, the present invention provides a method of easily assembling a separable transformer, which comprises a step of assembling a primary sub-module by mounting a primary core of the separable transformer to a primary unit and by carrying out electric wiring, and a step of assembling a secondary sub-module by mounting a secondary core of the separable transformer to a secondary unit and by carrying out electric wiring, and a step of assembling the primary sub-module and the secondary sub-module together, with the primary core and the secondary core disposed opposite to each other.

### DISCLOSURE OF THE INVENTION

[0010] In a case where the separable transformer is comprised of a rotary transformer including a stator core mounted to a stationary member and a rotor core mounted to a rotary member, the present invention is achieved by separately assembling the primary sub-module and the secondary sub-module into a stator side sub-module and a rotor side sub-module, respectively, and by assembling these sub-modules together, thereby assembling the rotary transformer. Thus, a separable-transformer assembling method is provided, which can facilitate an operation of assembling a separable transformer even if a rotary transformer is mounted to a steering unit.

[0011] In a case where the primary core comprises a stator core adapted to be mounted to a stationary

member and the secondary core comprises a rotor core adapted to be mounted to a rotation shaft that is rotatably supported by the stationary member, a separable-transformer assembling method of the present invention is achieved by providing the rotation shaft with a guide member having a first reference face defining a reference position in a diametrical direction of the rotation shaft and a second reference face defining a reference position in an axial direction of the rotation shaft, and by mounting the stator core and the rotor core individually to the stationary member and the rotation shaft with reference to the first and second reference faces of the guide member. By mounting the stator core and the rotor core with reference to the reference faces of the guide member, the positional relation between the cores is set precisely only by a simple operation.

**[0012]** Preferably, the stator core is positioned with respect to the rotation shaft through a jig, mounted to the guide member, and is mounted to the stationary member. Further, the rotor core is relatively movably mounted to the rotary member and temporarily held by the rotation shaft, and the rotor core, abutting against the guide member, is positioned with respect to the rotation shaft and fixed to the rotation shaft together with the rotary member.

**[0013]** In a case where the primary core comprises a stator core adapted to be mounted to a stationary member and the secondary core comprises a rotor core adapted to be mounted to a rotation shaft that is rotatably supported by the stationary member, a separable-transformer assembling method of the present invention is achieved by mounting the stator core and the rotor core individually to the stationary member and the rotation shaft with reference to those reference portions on the stationary-member side which define a rotation center and a mounting position of the rotation shaft, or with reference to auxiliary reference portions defined in advance with reference to the reference portions. More specifically, the present invention is characterized in that the cores are mounted with reference to the rotation shaft, or the bearing mechanism which rotatably supports the rotation shaft, or a reference face of a bracket whose position is precisely adjusted in advance with respect to the bearing mechanism.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]**

Fig. 1 is a sectional view, showing a first embodiment of the present invention, for explaining a structure and an assembling procedure of a steering module including a rotary transformer;

Fig. 2 is a sectional view for explaining a structure and an assembling procedure of a shaft module shown in Fig. 1;

Fig. 3 is a sectional view for explaining a structure and an assembling procedure of a steering wheel

module shown in Fig. 1;

Fig. 4 is a sectional view showing an assembled state of a module including a rotary transformer according to a second embodiment of the invention; Fig. 5 is a sectional view for explaining a structure and an assembling procedure of a stator-side module shown in Fig. 4;

Fig. 6 is a sectional view for explaining a structure and an assembling procedure of a rotor-side module shown in Fig. 4;

Fig. 7 is a sectional view, showing a third embodiment of the present invention, for explaining a structure and an assembling procedure of a steering module including a rotary transformer;

Fig. 8 is a sectional view, showing a fourth embodiment of the present invention, for explaining a structure and an assembling procedure of a steering module including a rotary transformer; and

Fig. 9 is a sectional view, showing a fifth embodiment of the present invention, for explaining a structure and an assembling procedure of a steering module including a rotary transformer.

## BEST MODE FOR CARRYING OUT THE INVENTION

**[0015]** With reference to the drawings, separable-transformer assembling methods according to embodiments of the present invention will be explained while taking, as an example, a rotary transformer adapted to be mounted to an automotive steering unit.

[First Embodiment]

**[0016]** As shown in Fig. 1, a rotary transformer (separable transformer) 10 includes a primary core (stator core) 11 provided on the side of a shaft module 20 of an automobile and a secondary core (rotor core) 12 provided on the side of a steering wheel module 30 that is mounted to the shaft module 20 and serves as a rotary member. The cores 11 and 12 are coaxially disposed so as to be opposed to and out of contact with each other at a predetermined distance. For instance, the rotary transformer 10 serves to make contactless transmission of electric energy between the primary core 11 and the secondary core 12, the electric energy being supplied from a battery (not shown) on the side of the stationary member to initiate the inflation of an air bag apparatus (not shown) incorporated on the side of the steering wheel module 30.

**[0017]** The shaft module 20 including the primary core 11 is assembled in advance as shown in Fig. 2 in a sub-assembly line (shaft-module assembly line) of an automotive assembly line. The steering wheel module 30 including the secondary core 12 is assembled as shown in Fig. 3 in another sub-assembly line (steering-wheel-module assembly line) of the automotive assembly line. Thereafter, these sub-modules 20 and 30 are supplied to a main assembly line (vehicle assembly line)

in the automotive assembly line, and are assembled into the form of a steering wheel module 40 including the separable transformer 10 as shown in Fig. 1.

**[0018]** More specifically, as shown in Fig. 2, the shaft module (primary-side module) 20 is assembled into a primary sub-module by mounting the primary core 11 of the separable transformer 10 to a primary-side unit 25 comprising a steering shaft 21, a column shaft 22 and the like.

**[0019]** That is, the primary-side unit 25 is assembled such that the steering shaft 21 is rotatably supported by the cylindrical column shaft 22 and that one end portion of the steering shaft 21 longitudinally projects beyond an end face of the column shaft 22. The assembled primary-side unit 25 is supplied to the sub-assembly line. An end portion 21a of the steering shaft 21, projecting beyond the end face of the column shaft 22, is formed to have such a small diameter as to permit a boss 31b of a steering wheel 31, described later, to be fixedly fitted thereon in a state that it abuts against a stepped portion 21b of the steering shaft, which determines the mounting position of the boss 31b. The end portion 21a of the steering shaft has a tip end section thereof formed with a threaded groove 21s with which the steering wheel boss 31b is fixed. As will be described later, the stepped portion 21a serves to determine a distance (gap length) between the opposed primary and secondary cores 11 and 12 when the shaft module 20 and the steering wheel module 30 are assembled together.

**[0020]** The column shaft 22 is formed at one end portion with an annular flange 22f on which the primary core 11 of the rotary transformer 10 is mounted. The primary core 11 constituting the rotary transformer 10 is adhered and fixed to an upper face of the flange 22f using an adhesive G made of two-part mixture type epoxy resin.

**[0021]** The primary core 11 comprises a flat plate-like ring of a predetermined thickness made of mixed soft magnetic material including insulative material, having electrical insulating properties, and soft magnetic material. A ring-like primary coil 11c is embedded in one end face of the primary core 11 coaxially therewith. The one end face is formed into a flat coupling face for electromagnetic coupling between itself and the secondary core 12. A circular hole 11b formed in a central portion of the primary core 11 has such a size as to permit the steering wheel shaft 21 to pass therethrough. The primary core 11 is formed at another end face with a ring-like groove 11s for positioning the primary core 11.

**[0022]** To mount the primary core 11 to the primary-side unit 25, adhesive G is first applied to the upper face of the flange 22f of the column shaft 22. A positioning jig 26 is attached to the flange 22f, while taking a lower face and an outer peripheral face of the flange 22f as the reference. With another end face, formed with the groove 11s, of the primary core 11 directed downward,

the primary core 11 is mounted to the flange 22f from above, while permitting the steering shaft 21 to pass through the circular hole 11b formed therein; so that the primary core 11 is superposed on the flange 22f. At this time, a claw 26a of the positioning jig 26 is fitted into the groove 11s, whereby the primary core 11 is positioned coaxially with the flange 22f (column shaft 22) at an accurate vertical position. This state is kept until the adhesive G is cured. As a result, the primary core 11 is precisely fixed at a predetermined mounting position relative to the flange 22f (column shaft 22) and relative to the steering shaft 21 which is rotatably supported by the column shaft 22 through a bearing mechanism 23.

**[0023]** After the primary core 11 and the primary-side unit 25 are assembled (joined) together in this manner, the positioning jig 26 is removed. Subsequently, an electric wire 11e pulled out from the primary coil 11c of the primary core 11 is electrically connected with an electric wire 20e that is connected to the battery of the shaft module 20. For this electrical connection, a pair of connectors 24 are employed, for example. The operation of electric connection (wiring) can be done in an easy posture in the sub-assembly line, so that the operation efficiency may improve. Since no substantial restrictions are imposed in operation environment, it is possible to connect the electric wires 11e and 20e together by means of a connecting method which is inexpensive and of high reliability, such as ultrasonic welding, resistance welding, pressure welding, soldering or the like, instead of making the electrical connecting operation using the connectors 24.

**[0024]** With the above-described assembling operation, the primary core 11 is mounted to the end face of the column shaft 22 on the side of the primary unit 25, thereby completing the assemblage of the shaft module (primary module) 20 for which electric wiring has been made. If the primary core 11 can be fixed precisely and rigidly to the end face of the column shaft 22, it is not inevitably necessary to provide the flange 22f in the column shaft 22.

**[0025]** On the other hand, the steering wheel module 30 is assembled by mounting the secondary core 12 of the separable transformer 10 to the boss 31b of the steering wheel 30 as shown in Fig. 3. The boss 31a is provided with a mounting hole 31c into which an end portion 21a of the steering shaft 21 can be inserted. The air bag apparatus (not shown) is incorporated in advance into the steering wheel 31.

**[0026]** Like the above-described primary core 11, the secondary core 12 mounted to the boss 31a comprises a flat plate-like ring having a predetermined thickness made of mixed soft magnetic material, including insulative material having electrical insulating properties and soft magnetic material. A ring-like secondary coil 12c is coaxially embedded in one end face of the secondary core 12. The one end face is formed into a flat coupling face for electromagnetic coupling with the primary core 11. A circular hole 12b formed in central

portion of the secondary core 12 has such a size as to permit an end portion 21a of the steering wheel shaft 21 to pass therethrough. The secondary core 12 is coaxially formed at its another end face with a ring-like groove 12s for positioning the secondary core 12.

**[0027]** With another end face of the secondary core 12, in which the secondary coil 12c is embedded, directed downward, the secondary core 12 is mounted to a lower face of the boss 31b using an adhesive. At this time, a claw 32a of the positioning jig 32 mounted to the outer peripheral face of the boss 31b is fitted into the groove 12s, thereby positioning the secondary core 12 with respect to the boss 31b. In this state, the adhesive is cured. Meanwhile, it is possible to directly mount the secondary core 12 to the lower face of the boss 31b with use of embedding bolts, which are adapted to be inserted into threaded holes formed in advance in the lower face of the boss 31b.

**[0028]** Thereafter, the positioning jig 32 is removed. An electric wire 12e pulled out from the secondary coil 12c of the secondary core 12 and an electric wire 31e pulled out from the air bag apparatus or the like incorporated in the steering wheel 31 are electrically connected to each other by using a connector apparatus 33. Since the electrical connecting operation (connection) can be done in an easy posture in the sub-assembly line, the operation efficiency can be improved. Since there is no substantial restriction in operation environment, moreover, it is possible to connect the electric wires 12e and 31e using a connecting method which is inexpensive and of high reliability such as ultrasonic welding, resistance welding, pressure welding, soldering or the like, instead of the electrical connecting operation using the connector apparatus 33.

**[0029]** The shaft module 20 and the steering wheel module 30 assembled in the sub-assembly lines (shaft module assembly line, steering wheel module assembly line) in the above-described manner are supplied to the main assembly line (vehicle body assembly line). In the main assembly line, the steering wheel module (secondary sub-module) 30 is mounted to the shaft module 20 already mounted on, e.g., a lower shaft of a vehicle body, while checking the rotary position of the shaft module 20.

**[0030]** More specifically, in mounting the steering wheel module 30 to the shaft module 20, the steering wheel module 30 is fitted on the shaft module 20 from above, while permitting an end portion 21a of the steering shaft 21 to pass therethrough, and serrations (not shown) formed in the end portion 21a are fitted into amounting hole of the boss 31a of the steering wheel 31 at an appropriate rotation angle. At that time, as shown in Fig. 1, a lower face of the boss 31b of the steering wheel 31 is brought to abut against the stepped portion 21b of the steering shaft 21, to thereby determine the mounting height of the steering wheel. By determining the mounting height of the steering wheel module 30 with respect to the shaft module 20 by the stepped por-

tion 21b, it is possible to precisely determine a distance between the primary core 11 and the secondary core 12 opposed thereto, i.e., a distance (gap length g) between respective one end faces (coupled faces) of the primary and secondary cores 11 and 12.

**[0031]** At that time, alignment jigs 41 each having a C-shaped cross section are fitted, from at least three directions, into the annular grooves 11s and 12s of the primary and secondary cores 11 and 12 from their upper and lower faces, whereby the primary core 11 and the secondary core 12 are coaxially positioned, as shown by way of example in Fig. 1. In this state, a nut 42 is threadedly engaged with the threaded groove 21s formed in the end portion 21a of the steering shaft 21, so that the steering wheel module 30 is rigidly mounted to the steering shaft 21, i.e., to the shaft module 20 integrally therewith. Thereafter, the alignment jigs 41 are removed, and the assembling operation of the steering module 40 is completed.

**[0032]** If the shaft module 20 and the steering wheel module 30 are assembled together in this manner, the primary core 11 and the secondary core 12, incorporated individually into the modules 20 and 30, are coaxially disposed such that they are opposed to each other at a predetermined distance (gap length g). That is, the primary core 11 and the secondary core 12 are mounted to the steering shaft 21 coaxially with each other with use of the grooves 11s and 12s, so that coaxial precision between the cores 11 and 12 is sufficiently ensured. Further, the mounting height of each of the cores 11 and 12 is determined by the flange 22f of the column shaft 22 and the stepped portion 21b of the steering shaft 21, and hence the distance between the cores 11 and 12 is determined with sufficient precision. As a result, even if the steering wheel 31 is rotated, the distance (gap length) between the opposed cores 11 and 12 is always kept constant, with the cores 11 and 12 kept opposed without causing deviation of their axes. Thus, the transmission characteristic of the rotary transformer 10 is sufficiently stably maintained. Therefore, even if the steering wheel assumes any rotary angle, it is possible to transmit electric power for initiating the inflation of the air bag apparatus from the primary core 11 to the secondary core 12 precisely and efficiently. Since the wiring operation related to the separable transformer 10 is already completed in the sub-module assembly step, it is unnecessary to newly carry out the wiring operation at the assembly step of the shaft module 20 and the steering wheel module 30.

**[0033]** In the case of producing and assembling step of automobiles, the air bag apparatus is mounted to the steering wheel module 20 after the steering wheel module 20 is fixed to the steering shaft 21 using the nut 42 as described above. To simplify the mounting operation of the steering wheel, it is conceivable that the steering wheel module 30 mounted with the air bag mechanism may be inserted into the steering shaft 21, and they may be fixed together with use of horizontal

bolt and nut (not shown) corresponding to the nut 42. In such a case, if electrical wiring for the shaft module 20 and the steering wheel module 30 is carried out just after they are assembled together, the assemblage of the rotary transformer 10 and the fixing of the steering wheel to the steering shaft 21 can be made only by assembling the steering wheel module 20 using the horizontal bolt and nut. This facilitates the workability.

**[0034]** The separable transformer 10 incorporated in the steering wheel module 40 is not necessarily limited to one for initiating the inflation of the air bag apparatus, and can be used for contactless signal transmission from the cruise control apparatus connected to the secondary core 12 to the primary core 11.

**[0035]** The above-described separable-transformer assembling method can also be applied to a case where the primary and secondary cores constituting the separable transformer are disposed in a vehicle body module and a door module, respectively, so as to supply electric power for inflation to a side-air-bag apparatus accommodated in a door module, or electric power to a defroster hot wire of a door mirror, or electric power for driving a power-window motor. The separable-transformer assembling method can also be applied to a case where the primary and secondary cores of the separable transformer are respectively provided in an instrument panel module and a vehicle body module, so as to transmit control signals for, e.g., an air conditioner from an operating section of an instrument panel to a controller mounted to the vehicle, or supply driving electric power from the side of a vehicle body to an electrically-powered-seat driving motor mounted to a seat. In such cases, necessary electrical wiring for the primary and secondary cores 11, 12 can be carried out at the sub-module stage, so that the assembling workability can be improved.

#### [Second Embodiment]

**[0036]** To restrain a deviation of the rotation center of each of the stator core (primary core) 11 and the rotor core (secondary core) 12 within a predetermined range, and to restrain a deviation of the gap length  $g$  between the stator core 11 and the rotor core 12 within a predetermined range, thereby maintaining the transmission efficiency of the rotary transformer 10 at a constant level, it is possible to constitute the steering wheel module 40 by incorporating the steering wheel module 30 into the shaft module 20 so as to be rotatable, as shown by way of example in Fig. 4. A second embodiment shown in Fig. 4 is intended, in particular, to determine mounting positions of the stator core 11 and the rotor core 12 by using a guide positioning member 27 that is mounted to the steering shaft 21, thereby assembling the steering wheel module 40 in a state that the cores 11 and 12 are precisely positioned.

**[0037]** The second embodiment will be explained. The shaft module 20 incorporating therein the stator

core (primary core) 11 comprises a steering shaft 21, a column shaft 22, the guide positioning member 27 and the like, as shown in Fig. 5.

**[0038]** More specifically, the steering shaft 21 coaxially and rotatably supported by the cylindrical column shaft 22 through a bearing mechanism 23 is formed such that a peripheral face of the steering shaft 21 has a high degree of roundness and the outer diameter of the steering shaft 21 is precise. The bearing mechanism 23 supporting the steering shaft 21 has a rotation face extending perpendicular to the rotation axis of the steering shaft 21, and the bearing mechanism 23 is formed with high precision such as to coaxially rotatably support the steering shaft 21 without inclination. Especially, the steering shaft 21 is configured to permit a snap ring 28 to be fitted into a groove 21c formed in a predetermined reference position on a peripheral face of a lower end portion of the steering shaft 21, with the snap ring 28 abutting against an upper face of the bearing mechanism 23. Thus, the steering shaft 21 is precisely supported at a predetermined vertical position relative to the bearing mechanism 23. The bearing mechanism 23 is precisely positioned and mounted to a predetermined position inside the column shaft 22.

**[0039]** The guide positioning member 27 fitted around the outer periphery of the steering shaft 21 is comprised of a cylindrical body having such an inner diameter as to permit the steering shaft 21 to be fitted therein with a predetermined dimensional tolerance. The cylindrical body is formed into a shape such that a ring-like flange 27f is provided at a central portion of its outer peripheral face. The guide positioning member 27 is fitted around a proximal portion of the steering shaft 21 so as to be mounted to the steering shaft 21 coaxially therewith, whereby it is precisely positioned and mounted to the bearing mechanism 23 through the snap ring 28 in a state that its lower end portion is abutted against an upper face of the snap ring 28.

**[0040]** In the guide positioning member 27, an upper face of the flange 27f serves as a gap reference face 27g for precisely determining a distance (gap length) between the stator core (primary core) 11 and the rotor core (secondary core) 12 opposed thereto, and a cylinder peripheral face of the flange 27f on the upper face side serves as a concentric reference face 27c, which is coaxial with the steering shaft 21, for coaxially positioning the stator core (primary core) 11 and the rotor core (secondary core) 12. By machining, with high precision, the guide positioning member 27 fabricated by injection molding or the like, the reference faces 27g and 27c are formed in advance into a flat face and a circumferential face which extend perpendicular to and coaxially with the axis of the guide positioning member 27, respectively, and which satisfy predetermined dimensional precision (tolerances) and face finishing precision so as to provide predetermined positioning precision. The outer diameter of the flange 27f is set smaller than the inner diameter of the stator core (pri-

mary core) 11 incorporated in the shaft module 20.

**[0041]** The stator core (primary core) 11 is substantially the same as that of the aforementioned embodiment. In the present embodiment, but a primary coil 11x for transmitting great electric energy for initiating inflation of an air bag apparatus and a primary coil 11y for transmitting control signal to a cruise control apparatus are disposed coaxially with each other.

**[0042]** To mount the primary core 11 including such primary coils 11x and 11y to the shaft module 20, a paste adhesive such as a two-part mixture type epoxy-base adhesive is first applied to the upper face of the flange 22f of the end portion of the column shaft 22. Then, the primary core 11 is fitted around the steering shaft 21 from above and placed on the upper face of the flange 22f to which the adhesive is applied. Thereafter, four block-like stator-core positioning jigs 29 supporting the primary core 11 from four directions, for example, are mounted to the outer peripheral face of the primary core 11 such that the positioning jigs 29 are brought in abutment against the guide positioning member 27, thereby determining the mounting position of the primary core 11 with high precision.

**[0043]** More specifically, the block-like stator-core positioning jigs 29 are each comprised of a rectangular parallelepiped block that has one side portion thereof provided with a claw 29n, adapted for core engagement, for holding the outer peripheral face of the primary core 11. These positioning jigs 29 are mounted in close contact with the upper face 11q and the outer peripheral face 11p of the primary core 11. The stator-core positioning jigs 29 each have another side portion thereof formed with a stepped portion 29s which abuts against the two reference faces 27g and 27c of the guide positioning member 27. The stator-core positioning jigs 29 are fabricated in advance with a high dimensional precision, as in the case of the guide positioning member 27, so that the positional relation between the stepped portion 29s and a holding face of the primary core 11 may be determined with high precision. The stator-core positioning jigs 29 are mounted in close contact with the upper face 11q and the outer peripheral face 11p of the primary core 11 in a state that the stepped portions 29s abut against the two reference faces 27g and 27c of the guide positioning member 27, thereby accurately determining the mounting position of the primary core 11 with reference to the reference faces 27g and 27c.

**[0044]** As a result, the primary core 11 placed on the upper face of the flange 22f is positioned with high precision in the diametrical and axial directions of the steering shaft 21 with reference to the reference faces 27g and 27c of the guide positioning member 27 through the stator-core positioning jigs 29. That is, the primary core 11 is disposed coaxially with the steering shaft 21 at a predetermined height relative to the upper face of the snap ring 28 (bearing mechanism 23) serving as a reference position. This state is kept until the adhesive is cured, whereby the primary core 11 is posi-

tioned and mounted on the flange 22f of the column shaft 22 with high precision. Thereafter, the stator-core positioning jigs 29 are removed, and the assembling operation of the primary core 11 to the shaft module 20 is completed. Then, electric wires 12e pulled out from the primary coils 11x and 11y are connected to the shaft module 20, as described above.

**[0045]** In the meantime, the primary core 11 may be placed on the upper face of the flange 22f while permitting the steering shaft 21 to be inserted therein, after a plurality of the stator-core positioning jigs 29 are mounted in advance to a peripheral face of the primary core 11. In such a case, the stepped portions 29s of the stator-core positioning jigs 29 may be fitted, along the reference face 27g of the guide positioning member 27, up to positions where they abut against the reference face 27c.

**[0046]** On the other hand, the steering wheel module 30 has a structure such that the rotor core (secondary core) 12 is mounted to the boss 31b of the steering wheel 31 through the rotor-core fixing member 32 as shown by way of example in Fig. 6. The rotor core (secondary core) 12 is formed into a disk-like shape like the stator core (primary core) 11. In one side face of the rotor core 12, a secondary coil 12x for transmitting electric power for initiating inflation of the air bag apparatus and a secondary coil 12y for transmitting signal to the cruise control apparatus are coaxially disposed.

**[0047]** A through hole 12b, to which the concentric reference face 27 is fitted with a predetermined dimensional tolerance, is formed in a central portion of the secondary core 12. An inner peripheral face of the through hole 12b serves as a concentric reference face 12c which is coaxial with the secondary core 12. The concentric reference face 12c, abutting against the peripheral face (gap reference face 27g) of the guide positioning member 27, serves to position the secondary core 12 coaxially with the guide positioning member 27 and the steering shaft 21. The central portion of that face of the secondary core 12 on which the secondary coils 12x and 12y are disposed is formed into a recess having a predetermined depth. A bottom of the recess serves as a gap reference face 13g which extends in parallel to a coil disposing face 13q. The gap reference face 13g, abutting against the gap reference face 27g of the guide positioning member 27, serves to determine the mounting height of the secondary core 12 with use of the guide positioning member 27 as a reference. That is, the gap reference face 13g serves to position the coil disposing face 12q of the secondary core 12 at a predetermined height from that one side end face of the snap ring 27 which is the reference position in the longitudinal direction of the steering shaft 21.

**[0048]** The secondary core (rotor core) 12 having the above-described structure is mounted to a lower portion of the boss 31b of the steering wheel module 30 through the cylindrical rotor-core fixing member 32 having opposite ends thereof provided with flanges. The

rotor-core fixing member 32, which includes a cylindrical portion of a diameter greater than that of the center hole 12b of the secondary core 12 through which the steering shaft 21 can be inserted, is fixed on the upper face of the secondary core 12 substantially coaxially therewith. The secondary core 12 and the lower flange of the rotor-core fixing member 32 are fixed together by means of adhesive or screw.

**[0049]** To mount the secondary core 12, fixed in advance at its upper face with the rotor-core fixing member 32, to the boss 31b, the upper-end side flange of the rotor-core fixing member 32 is disposed so as to be supported at its lower face by inwardly projecting lower ends 33a of the connection jigs 33, with use of L-shaped connection jigs 33 which are, e.g., four in number and mounted to the peripheral face of the boss 31b at equal distances as shown in Fig. 6. At that time, an O-ring 34 is interposed between an end face of the upper end side flange of the rotor-core fixing member 32 and the lower face of the boss 31b. Each of the connection jigs 33, supporting the rotor-core fixing member 32, serves to temporarily hold the rotor-core fixing member 32 on the lower face of the boss 31b so as to be moveable in the vertical and diametrical directions within a predetermined range. By holding the rotor-core fixing member 32 temporarily in this manner, the later-mentioned operation of mounting the steering wheel module 30 to the shaft module 20 is facilitated.

**[0050]** In such an assembled state, the electric wires 12e pulled out from the secondary coils 12x and 12y of secondary core 12 are electrically connected (connection) to the air bag apparatus (not shown) incorporated in the steering wheel 31, whereby the assembling operation of the steering wheel module (secondary sub-module) 30 is completed.

**[0051]** The steering wheel module (secondary sub-module) 30 is mounted to the shaft module 20 in the following manner. That is, the rotor-core fixing member 32 and the secondary core 12, formed with the through hole 12b and incorporated in the steering wheel module (secondary sub-module) 30 having the boss 31b formed with a mounting hole, are inserted from above the steering shaft 21 of the shaft module 20, as shown in Fig. 4. The steering wheel module 30 is fitted to the serrations formed around the end portion 21a of the steering shaft 21 at a predetermined rotation angle, and the nut 42 is lightly (loosely) threaded to a screw portion 21s formed at a tip end of the steering shaft 21.

**[0052]** At that time, the concentric reference face 12c of the secondary core (rotor core) 12 which is temporarily held by the connection jig 33 with a predetermined play is fitted, with predetermined tolerances, to the concentric reference face 27c which is the outer peripheral face of the guide positioning member 27, thereby positioning the secondary core 12 with respect to the steering shaft 21 coaxially. At the same time, the gap reference face 12g of the secondary core (rotor core) 12 is pressed against the gap reference face 27g

which is the upper face of the flange 27f of the guide positioning member 27, thereby determining the mounting height of the secondary core 12. In this state, the nut 42 is rigidly threaded to the screw portion 21s, thereby completely fastening the boss 31b of the steering wheel 31 in the longitudinal direction of the steering shaft 21.

**[0053]** Thus, the secondary core 12 is sandwiched between the lower face of the boss 31b and the upper face of the flange 27f of the guide positioning member 27 through the rotor-core fixing member 32, and the fastening force of the nut 42 is transmitted to the secondary core 13 through the O-ring 34 and the fixing member 32, and the gap reference face 12g of the secondary core 12, so that the gap reference face 27g of the guide positioning member 27 are reliably brought in abutment against each other. At that time, the O-ring 34 is deformed to absorb a positional deviation of the secondary core 12 which abuts against the guide positioning member 27 to determine its mounting position and a positional deviation of the boss 31b of the steering wheel 31 mounted to the steering shaft 21 using the nut 42. The mounting height position of the secondary core 12 is determined by the guide positioning member 27, and the secondary core 12 is coaxially mounted through the guide positioning member 27 to the steering shaft 21 at a predetermined height position measured from the reference position determined by the snap ring 28.

**[0054]** Thereafter, the connection jigs 33 are removed, and the assembling operation of the steering wheel module 40, performed by mounting the steering wheel module 30 to the shaft module 20, is completed.

**[0055]** According to this assembling method, the guide positioning member 27 is coaxially fitted to the steering shaft 21, using the bearing mechanism 23, incorporated in the column shaft 22 and pivotally supporting the steering shaft 21, as an axial reference position of the steering shaft 21. Utilizing the concentric reference face 27c and the gap reference face 27g formed on the guide positioning member 27 and using the stator-core positioning jig 29, the primary core (stator core) 11 is positioned and fixed to the end of the column shaft with high precision. Further, utilizing the concentric reference face 27c and the gap reference face 27g formed on the guide positioning member 27, the secondary core (rotor core) 12 is positioned and mounted with high precision to the guide positioning member 27. As a result, the primary core (rotor core) 11 and the secondary core (rotor core) 12 are positioned with reference to the common concentric reference face 27c and the gap reference face 27g of the guide positioning member 27. Therefore, the cores 11 and 12 are disposed in parallel so as to be opposed to each other at a predetermined distance in the direction perpendicularly to the axis of the steering shaft 21 and disposed coaxially with the steering shaft 21 without misalignment. Therefore, the opposed positional relation between the cores 11 and 12 is not varied by the rotation of the steering wheel 31 and hence the transmis-



sion efficiency of signal or energy between the cores 11 and 12 does not vary, making it possible to assemble the separable transformer (rotary transformer) 10 having stable performance.

[0056] The number of the stator-core positioning jigs 29 and the connection jigs 33 may not be four as in the above embodiment, and the provision of three or more jigs disposed in the circumferential direction will suffice. Further, instead of fixing the primary core (stator core) 12 to the end portion of the column shaft 22 using adhesive, the primary core 12 can be screwed to the column shaft 22 in a state that a spacer (not shown) having appropriate thickness is interposed between the end portion of the column shaft 22 and the primary core 12. More specifically, the primary core 12 can be fixed to the column shaft 22 using screws or the like in a state that the stator-core positioning jigs 29 are brought in engagement with the guide positioning member 27 and the primary core (stator core) 12 and the spacers having different thickness are interposed at predetermined positions between the stator core 12 and the flange 22f of the column shaft 22. The connection jigs 33 may be kept mounted to the boss 31b.

#### [Third Embodiment]

[0057] To mount the secondary core (rotor core) 12 to the boss 31b, connection members 35 may be used, which are temporarily held on the peripheral face of the boss 31 such that their axial positions can be adjusted as shown in Fig. 7. That is, the secondary core (rotor core) 12 is mounted to lower portions of the plurality of connection members 35 which are temporarily held on the peripheral face of the boss 31b of the steering wheel module 30 at equal distances circumferentially of the boss, the O-ring 34 is interposed between the secondary core (rotor core) 12 and the boss 31b, and the secondary core (rotor core) 12 is mounted to the boss 31b so as to be axially moveable. The steering shaft 21 is fabricated such as to have sufficiently high degree of roundness as in the foregoing embodiment. The bearing mechanism 23 supporting the steering shaft 21 is also fabricated with high precision such that it has the rotation face thereof extending perpendicularly to the rotation axis of the steering shaft 21, thereby rotatably coaxially supporting the steering shaft 21 without inclination. In this case, the guide positioning member 27 is formed shorter than that of the second embodiment.

[0058] In a positioning state that the secondary core (rotor core) 12 is brought into abutment against the guide positioning member 27, the boss 31b is fixed to the steering shaft 21 and the connection members 35 are rigidly fixed to the peripheral face of the boss 31b.

[0059] Even when the secondary core (rotor core) 12 is mounted to the steering wheel module 30 with use of the connection members 35 such that the core 12 can move in only the axial direction, the secondary core (rotor core) 12 is positioned coaxially with the steering

shaft 21 with reference to the guide positioning member 27. As a result, even if the boss 31b of the steering wheel 31 mounted to the steering shaft 21 is deviated from the steering shaft 21, it is possible to keep a positional relation between the primary core (stator core) 11 and the secondary core (rotor core) 12 so as to maintain a state (positional relation) where these cores oppose in parallel to each other at a predetermined distance in the axial direction, irrespective of rotation of the steering shaft 21.

#### [Fourth Embodiment]

[0060] A fourth embodiment is intended to carry out the assembling operation in which the steering shaft 21, fabricated to have a sufficiently high degree of roundness, or the bearing mechanism 23, fabricated with high precision and rotatably supporting the steering shaft 21 or the like, is directly utilized as references (reference portions) for positioning the primary core (stator core) 11 and the secondary core (rotor core) 12. That is, the steering shaft 21 is fabricated to have the degree of roundness which is sufficiently high, and the bearing mechanism 23 supporting the steering shaft 21 is fabricated with high precision to have the rotation face extending perpendicularly to the rotation axis of the steering shaft 21 and so as to rotatably support the steering shaft 21 coaxially therewith without inclination.

[0061] In this embodiment, the bearing mechanism 23 provided between the steering shaft 21 and the column shaft 22 and rotatably supporting the steering shaft 21 serves as a reference portion for determining the mounting position of the primary core 11. With reference to an upper face of an outer race 23a of the bearing mechanism 23, the mounting height position of the primary core 11 is determined, and the primary core 11 is fixed to the column shaft 22. When the bearing mechanism 23 is provided at a portion recessed from the end portion of the column shaft 22, a ring-like spacer (not shown) having predetermined thickness may be mounted on the upper face of the outer race 23a of the bearing mechanism 23, so as to determine the mounting position of the primary core 11 through the spacer. The mounting position of the primary core 11 in the diametrical direction may be determined with reference to the peripheral face of the steering shaft 21 using a jig which is not shown.

[0062] On the other hand, the mounting position of the secondary core 12 is determined using, as the reference, an upper face of an inner race 23b of the bearing mechanism 23. More specifically, a spacer 46 having a predetermined length is mounted to the steering shaft 21, and the mounting height of the secondary core 12 is determined through the spacer 46. This spacer 46 is disposed between the secondary core 12 and the inner race 23b of the bearing mechanism 23 and mounted so as to rotate in unison with the secondary core 12. As the spacer 46, a sleeve, an oilless bush or the like is

employed, which is capable of maintaining the dimension of the gap  $g$  and the perpendicularity to the rotation plane of the bearing mechanism 23 (the degree of parallelization to the steering shaft 21). The position of the secondary core 12 in the diametrical direction is determined with reference to the peripheral face of the steering shaft 21. In this case, a through hole 12a is formed in advance, with high precision, at the center of the secondary core 12 such that an inner diameter of the through hole 12a meets an outer diameter of the steering shaft 21.

**[0063]** If the mounting of the primary core 11 and the secondary core 12 is performed with reference to the steering shaft 21 and the bearing mechanism 23, the gap length  $g$  between the cores 11, 12 and the perpendicularity to the rotation plane of the bearing mechanism 23 (the degree of parallelization to the steering shaft 21) are maintained. Thus, the performance of the rotary transformer 10 can be stably maintained, so that predetermined coupling efficiency may be attained. Since the primary core 11 and the secondary core 12 are easily mounted to the column shaft 22 and the steering shaft 21 which are excellent in machining precision, in a state they are positioned with reference to the bearing mechanism 23 and the steering shaft 21, the mounting operation is simplified.

[Fifth Embodiment]

**[0064]** If the location of a positioning portion, serving as the reference for assembling the rotary transformer 10, is precisely determined in advance, part of a component other than the bearing mechanism 23 may be utilized as an auxiliary reference position in the mounting operation for the primary core 11 and the secondary core 12. As shown by way of example in Fig. 9, if the location of a bracket 47 mounted to the column shaft 22 is precisely determined in advance with respect to the steering shaft 21, the primary core 11 may be positioned with reference to the bracket 47.

**[0065]** That is, if positions of an upper face FU and a side face FS of the bracket 47 mounted to the column shaft 22, as shown in Fig. 9, are accurately determined in advance with respect to the steering shaft 21, the primary core 12 may be mounted to the bracket 47 with reference to the faces FU and FS serving as the reference (auxiliary reference portions), using a desired guide plate 47a in combination therewith. In the case of the rotary transformer 10 incorporated in an automotive steering module, if the upper face FU and the side face FS of the bracket 47 are processed with positioning precision of  $\pm 0.5$  mm, the mounting position of the primary core 11 is determined within error range of  $\pm 0.5$  mm, so that sufficient effect can be expected.

**[0066]** To mount the secondary core 12 to the steering shaft 21, the mounting position may be determined by using the bracket 48 mounted to a predetermined position of the steering shaft 21. With this arrangement,

by simply using the steering shaft 21 and the brackets 47 and 48 serving as positioning portions, the primary core 11 and the secondary core 12 may be mounted. Therefore, it is possible to make the assemblage with ease while enjoying sufficiently high assembling precision.

**[0067]** Although the mounting method of the rotary transformer to the automotive steering unit has been explained in the foregoing embodiments, the present invention can be used for contactless electrical connection between robot arms having the freedom of rotation.

## INDUSTRIAL APPLICABILITY

**[0068]** According to the present invention, a primary sub-module and a secondary sub-module are assembled by carrying out desired electrical wiring after a primary core and a secondary core constituting a separable transformer are mounted individually to a primary-side unit and a secondary-side unit, and the separable transformer is assembled by combining these sub-modules. Therefore, the assemblage can be made efficiently with ease even when the transformer is mounted to an automotive steering mechanism. Further, electric wiring to coils of the modules can be easily carried out, and inexpensive connecting method such as crimp or welding can be used, if appropriate.

**[0069]** The primary core and the secondary core can easily and precisely be positioned, so that deviation of rotation center between the cores can be suppressed and the gap length can be maintained with high precision. Therefore, it is possible to sufficiently keep the transmission efficiency of the rotary transformer. Especially, the degrees of deviation and parallelization between the primary and secondary cores and the gap length can be maintained with high precision, to thereby easily realize a separable transformer having intended coupling efficiency.

## Claims

1. A method of assembling a separable transformer including a primary core and a secondary core disposed to be opposed to each other and adapted for contactless transmission of signal and/or energy between these cores, comprising the steps of:

mounting said primary core to a primary sub-module adapted to be provided with the primary core and carrying out electric wiring, to thereby assemble a primary sub-module; mounting said secondary core to a secondary sub-module adapted to be provided with the secondary core and carrying out electric wiring, to thereby assemble a secondary sub-module; and assembling said primary sub-module and said secondary sub-module together, with said pri-

mary and secondary cores opposed to each other.

with reference to said reference portions.

2. A method of assembling a separable transformer according to claim 1, wherein  
 said separable transformer constitutes a rotary transformer including a stator core mounted to a stationary member and a rotor core mounted to a rotary member, and  
 said primary sub-module and said secondary sub-module are separately assembled as a stator side sub-module and a rotor side sub-module. 5 10
  
3. A method of assembling a separable transformer according to claim 1, wherein  
 said primary core comprises a stator core mounted to a stationary member, and said secondary core comprises a rotor core mounted to a rotation shaft rotatably supported by said stationary member, said rotation shaft is provided with a guide member including a first reference face defining a reference position in a diametrical direction of the rotation shaft and a second reference face defining a reference position in an axial direction of the rotational shaft, and  
 said stator core and said rotor core are mounted to said stationary member and said rotation shaft with reference to said first and second reference faces of said guide member, respectively. 15 20 25 30
  
4. A method of assembling a separable transformer according to claim 3, wherein  
 said stator core is positioned relative to said rotation shaft through a jig mounted to said guide member and is mounted to said stationary member. 35
  
5. A method of assembling a separable transformer according to claim 3, wherein  
 said rotor core is relatively movably mounted to said rotary member and temporarily held by said rotation shaft, and said rotor core, abutting against said guide member, is positioned relative to said rotation shaft and fixed to said rotation shaft together with said rotary member. 40 45
  
6. A method of assembling a separable transformer according to claim 1, wherein  
 said primary core comprises a stator core mounted to a stationary member, and said secondary core comprises a rotor core mounted to a rotation shaft rotatably supported by said stationary member, and said stator core and said rotor core are respectively mounted to said stationary member and said rotation shaft with reference to reference portions located on a side of said stationary member and respectively defining a rotation center and a mounting position of said rotation shaft, or with reference to auxiliary reference portions defined in advance 50 55

FIG. 1

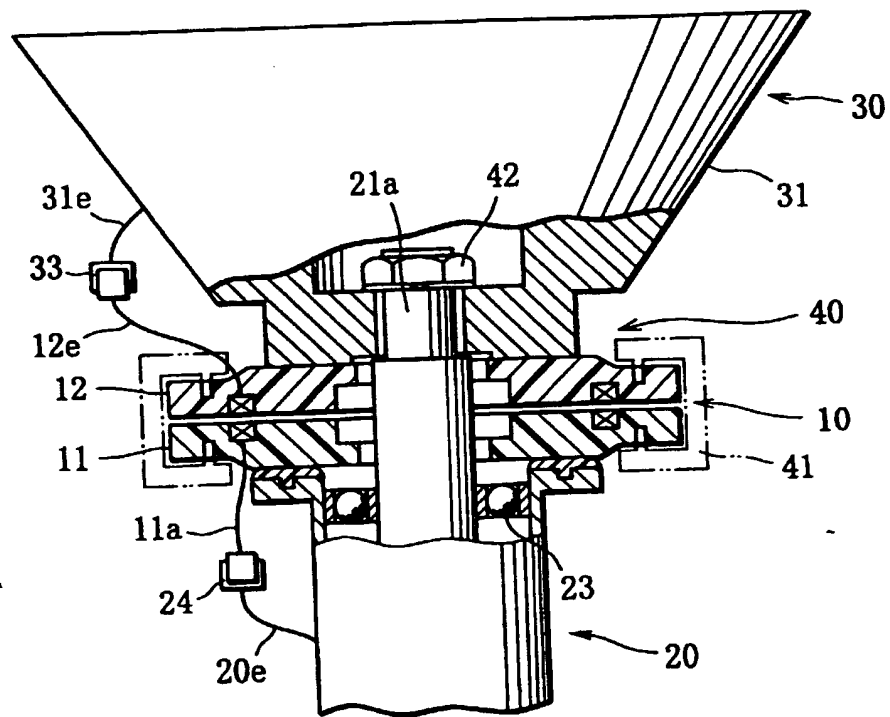


FIG. 2

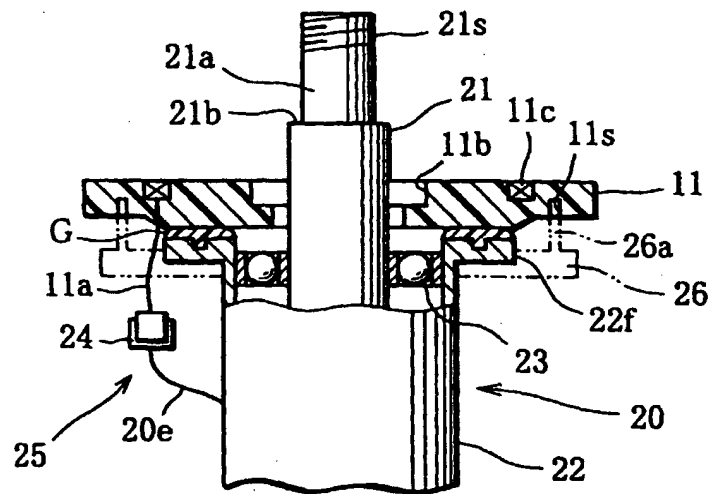


FIG. 3

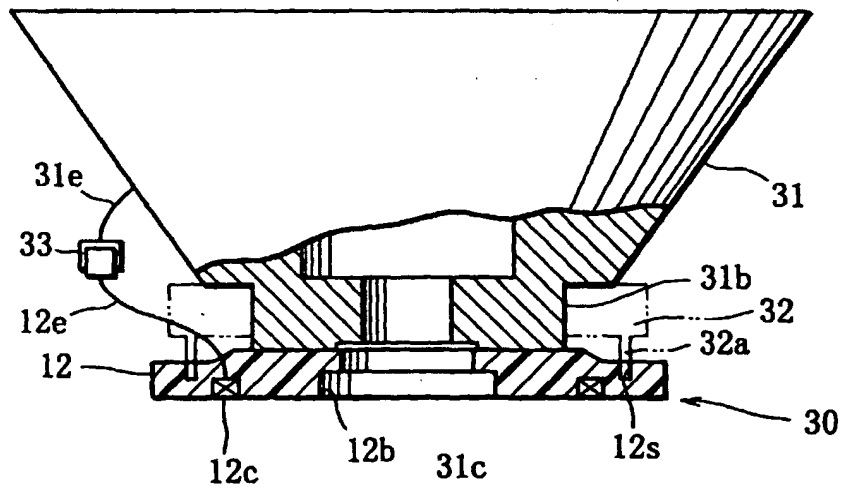


FIG. 4

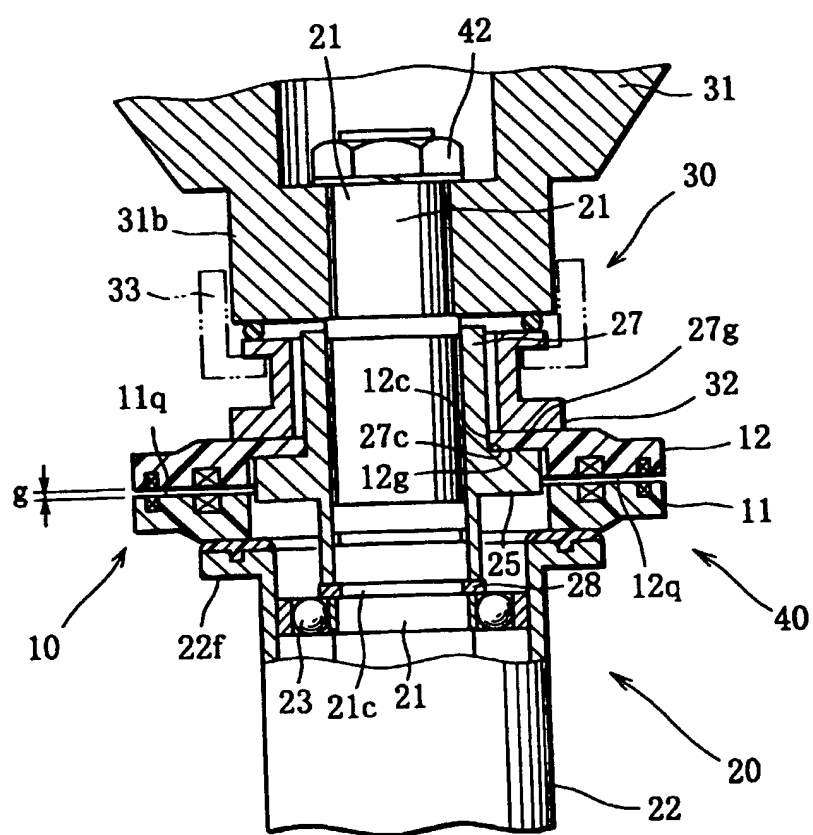


FIG. 5

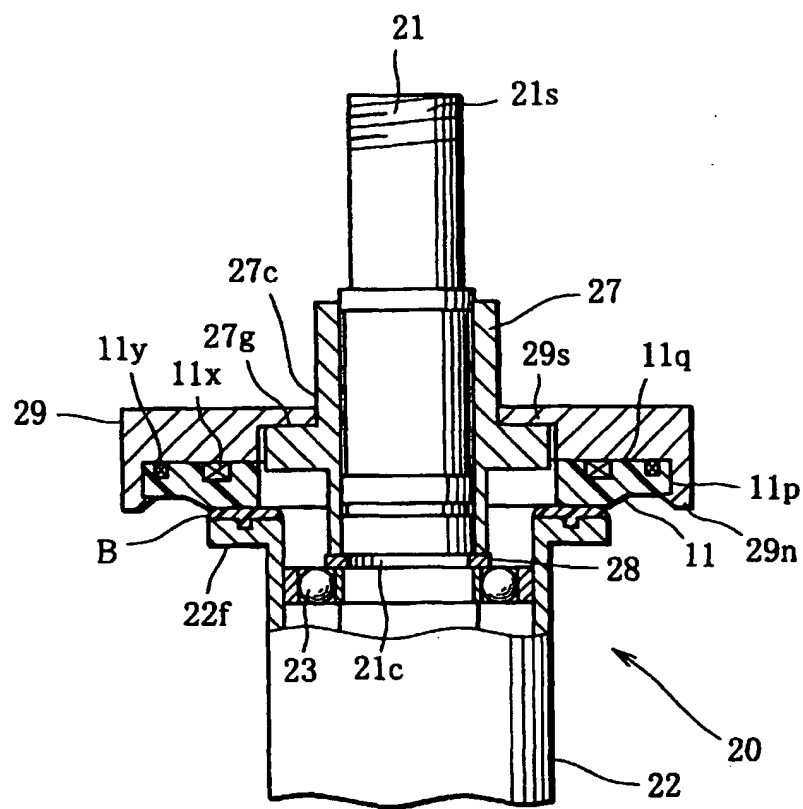


FIG. 6

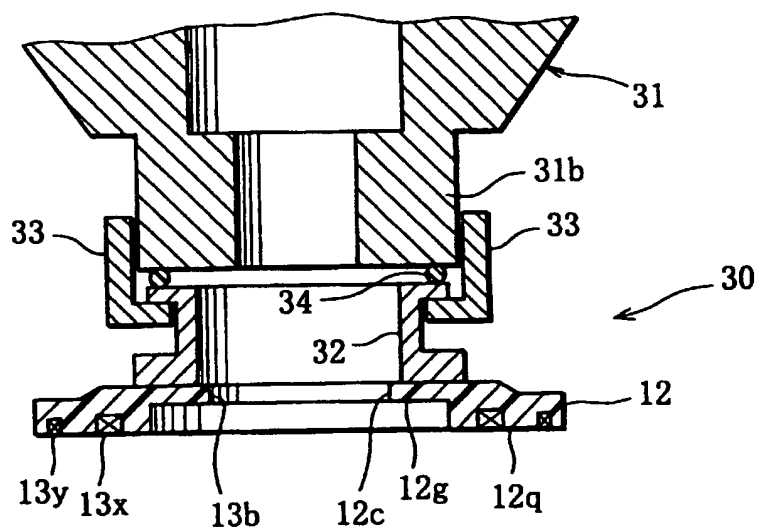


FIG. 7

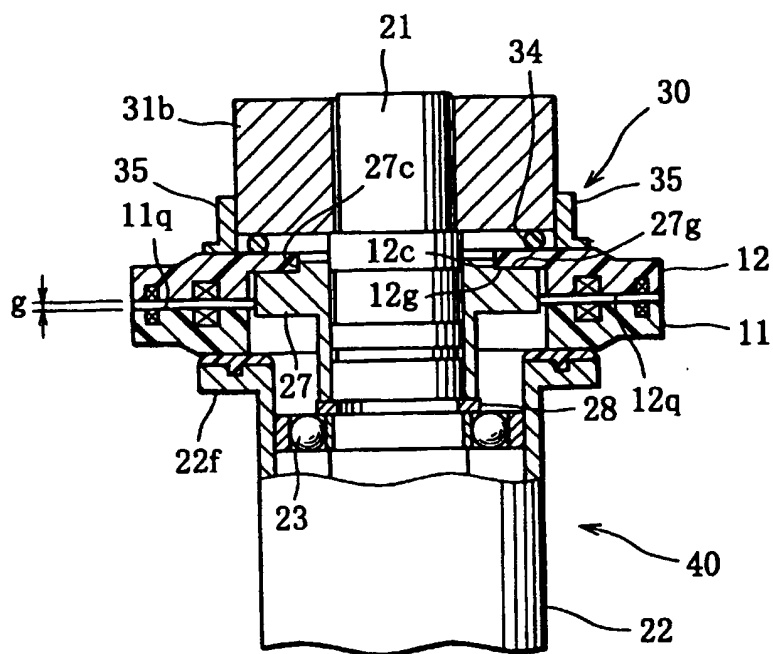




FIG. 8

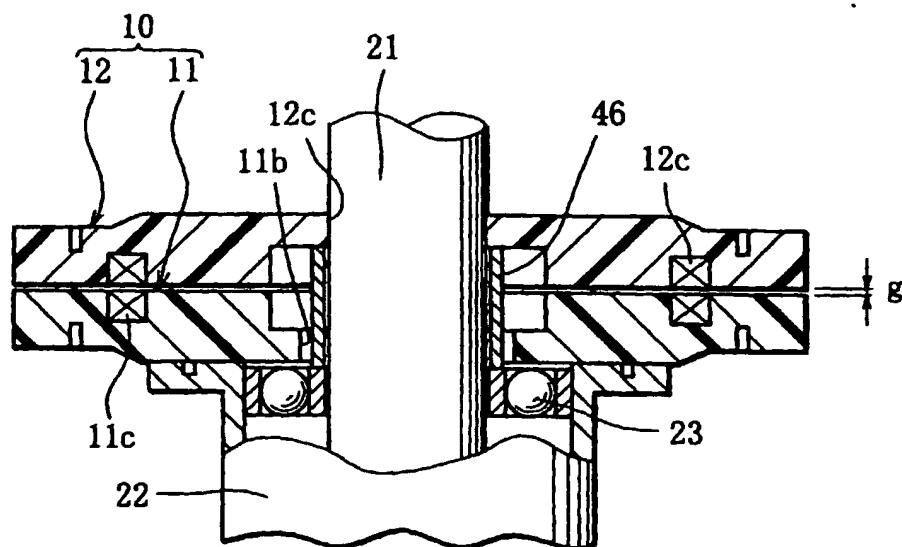
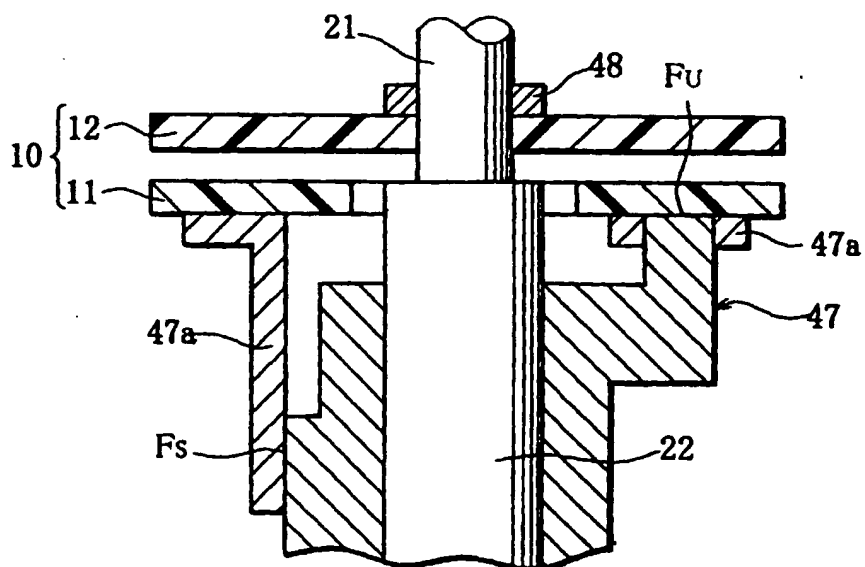


FIG. 9



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP99/03103

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int.Cl. <sup>8</sup> H01F38/14, H01F41/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) Int.Cl. <sup>8</sup> H01F38/14, H01F41/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-1999 Kokai Jitsuyo Shinan Koho 1971-1999 Jitsuyo Shinan Toroku Koho 1996-1999		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category <sup>a</sup>	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 55-52210, A (Tokyo Shibaura Electric Co., Ltd.), 16 April, 1980 (16. 04. 80), Claims (Family: none)	1-6
A	JP, 3-297109, A (Matsushita Electric Industrial Co., Ltd.), 27 December, 1991 (27. 12. 91), Claims (Family: none)	1-6
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
<sup>a</sup> Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reasons (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 16 July, 1999 (16. 07. 99)		Date of mailing of the international search report 3 August, 1999 (03. 08. 99)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)